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The following papers were read:—

1. *On the BONE-CAVES near CRENDI, ZEBBUG, and MELLIHA, in the ISLAND of MALTA.* By Captain T. A. B. SPRATT, R.N., C.B., F.R.S., F.G.S.

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I. INTRODUCTION.

This paper was, for the most part, written several years ago, but its publication has been delayed with a view to its accompanying the description of the remains of the extinct animals found within the several caverns, and more particularly the detailed description of the *Elephas Melitensis* (the Pigmy Elephant) by the late Dr. Hugh Falconer. His lamented and premature death causing a still further delay, it is now presented to the Society in anticipation of the immediate publication of Dr. Falconer's prepared drawings and final notes upon the Little Elephant, with other posthumous papers, under the editorship of his friend Dr. Murchison, F.R.S.,—and also in anticipation of an elaborate paper upon the same subject, which is being prepared by Mr. G. Busk, F.R.S., to whom the bones

were transferred at Dr. Falconer's decease. The bones of birds have been described by Mr. W. K. Parker, F.R.S. &c.*

II. THE MAGHLAK BONE-CAVE.

The first of these bone-caves was discovered in the summer of 1858, on the south coast of Malta, near the town of Crendi. That part of the coast, for a distance of about six miles on either side of the cavern, presents a line of almost precipitous cliffs or bold scarps, extending from Marsa Scirocco Bay, at the south-eastern extremity of Malta, to the small bay Fom el Rieh, at the north-western extremity and the base of the Bengemma heights or plateau.

These bold features terminate above in two distinct plateaux of nearly equal extent—the eastern plateau averaging a height of from 300 to 350 feet above the sea, and the western averaging about 800 feet and forming the summits of the before-named Bengemma heights.

The strata constituting these two plateaux lie nearly horizontal, there being a slight dip to the eastward throughout; and the origin of the plateaux is plainly due to the upper series of rather soft strata that rise up into the upper or western plateau having been entirely swept off from the lower and harder strata of calcareous sandstones and compact limestone by an encroachment of the sea, when it must have long remained about that level.

It was therefore the exposure of the harder stratum of limestone constituting the lowest of the series on the coast, near the village and well-known Phœnician ruin of Crendi, that led to the opening of a quarry there in 1858 for a durable stone suitable for the construction of the new naval dock, and, in the autumn of the same year, to the unexpected discovery of a bone-cave containing remains of the Hippopotamus and other animals. I therefore adopted the name of Crendi to distinguish the locality of the bone-cave and quarry, in my brief notice of the discovery laid before the Geological Society in 1859.

The late Mr. Horner, in his Presidential Address to the Society in 1861, consequently adopted the name of Crendi also for this quarry and cavern in his notice of the interesting discovery.

As Dr. Leith Adams, F.G.S., who arrived in Malta about two years subsequent to the first discovery of the cave, and whose more recent labours amongst its débris enabled him to procure similar remains, and to learn the history of the cavern both from the quarrymen and myself, adopted the local name of Maghlak, in a notice which he published respecting the cavern and its relics, in the Royal Dublin Society's Journal† and in his Report to the British Association‡, geologists have in consequence a somewhat confused familiarity with both names; it is therefore necessary for me to point out that they both apply to the same quarry and cavern.

At about the same level as the Crendi or Maghlak cavern, the crest cliffs overlooking the sea on both sides have indications of the

* Trans. Zool. Soc. vol. vi. p. 119.

† Vol. iv. p. 11.

‡ British Association Report, 1865, p. 259.

Fig. 1.—Sketch of some of the Cliffs and Caves of Malta.

former existence of several other caverns more or less shallow and open, more particularly on the west side, as shown in the sketch (fig. 1). None, however, contain any stalagmitic floor, or present any indication of bone breccia; and although generally wider and higher than the Maghlak Cavern, none of them penetrated so far inwards, except one, of very great interest, lying about 100 yards on the east side, between the Maghlak quarry and the lowest of the Phœnician temples of Crendi above alluded to, which has been very recently opened by Dr. Adams (see sketch), and found by him to be of such importance, from the special character of the larger mammalian remains, being those of Elephants* and not of Hippopotamus, as to have induced the British Association to grant to him the sum of £30 for its exploration; the results, as far as obtained, will therefore, I believe, form the subject of a Report by Dr. Adams.

Having proceeded to the Maghlak Quarry soon after the discovery of the bone-cavern within it, in company with my friend, W. Medlycott, Esq., we were shown numerous large blocks of its stalagmitic flooring, mingled with the talus of débris that had recently been ejected from the quarry, down the sea face of the scarp lying under it, and also upon a narrow natural terrace existing about half-way down. After some labour with our hammers amongst the blocks of bone-breccia found lying upon the talus, and upon this lower terrace, we were enabled to procure from them a few perfect teeth, and some nearly perfect tusks of the Hippopotamus; but from the extreme hardness of the stalagmitic bone-breccia, and the friable nature of the teeth, they in general crumble to chips under the heavy blow of the hammer necessary to fracture the hard matrix in which they are imbedded. The bones and teeth, however, were very numerous throughout these detached and fragmentary blocks, and showed that the remains of a large number of these animals were originally accumulated in the cavern, but indiscriminately, and that they consisted chiefly of the smaller bones of this mammal.

From close examination of the numerous fragments of bone-breccia, we were enabled to perceive that the flooring of the cavern consisted of two distinct layers of fossil bones. The lower, which must have been in some parts fully 3 and 4 feet thick, and composed of an indurated, brownish, stalagmitic clay, almost as hard as flint or jasper, contained in abundance well-rounded pebbles of the native rock, intermixed with the bones and teeth of the Hippopotamus; but these bones and teeth were not in general waterworn, as were the pebbles and shingle found with them; and consequently they were introduced into the cavern *after* its shingle floor had been raised above the surf-action of a surrounding sea, which no doubt produced both the caverns, and also rounded the pebbles, since there is no evidence or good reason to infer that either this cavern or the neighbouring caves on nearly the same level require any local river to account for their origin and position.

On comparing these teeth and tusks, immediately afterwards, with figures in Pictet's '*Paléontologie*,' I was led to refer them to the

* Geological Magazine, vol. ii. p. 490.

Hippopotamus, which conjecture was confirmed by Prof. Owen on the exhibition of the teeth in the Geological Society's rooms in 1859; and moreover they were then identified by him as the same species as that found so abundantly in the bone-caves near Palermo and in other parts of Sicily, viz. *H. Pentlandi*. These large mammalian remains were overlain by a bed of similar stalagmite of one foot or more in thickness, but without fossils, showing a period during which the Hippopotamus had become extinct; and this was succeeded by another stalagmitic bone-bed containing abundantly the bones and teeth of a Rodent, named *Myoxus Melitensis* by Dr. Falconer. Besides the Rodent bones, there were also the bones of Birds. From the fragments of the flooring scattered with the débris under the quarry, this upper stalagmitic crust enclosing the Rodent and Bird remains was seen to have varied in thickness from 6 or 8 inches to a foot or more in some parts of the cavern.

On ascending to the quarry to learn from the quarrymen more of the nature of the cavern when first discovered, we were informed that it did not extend inwards more than about 40 or 50 feet from the face of the cliff; and at about that distance from it, within the quarry, we were shown a portion of its stalagmitic flooring *still in situ*, forming what appeared to have been the termination of a narrow recess at the inner end of the cavern. This fragment of bone-breccia *in situ* exhibited the same arrangement as above described from the débris of fragments ejected from the quarry; that is, the Hippopotamus-remains were entirely confined to the lower stratum, and the Rodent and Bird-bones, with land shells of living species, to the upper; but it was composed at this part *in situ* of about a foot of thinly stratified stalagmitic layers, with red earth or clay between them, whence I swept up several handfuls of the fragments of Bird-bones, and of the teeth and bones of the Rodent *Myoxus Melitensis*, so named by Dr. Falconer, and described in a letter to me soon afterwards as a Dormouse of twice or thrice the size of the existing species.

III. THE ZEBBUG OSSIFEROUS CAVERN.

Two years subsequent to the discovery of the bone-cave near Crendi, another of more startling interest was discovered, in the centre of the island, near the large town of Zebbug. It was accidentally struck upon in sinking an excavation for a tank, upon the upper of the two terraces forming the garden of Signor Buttiegieg, on the north side of the rocky valley separating the towns of Zebbug and Seggieni. The excavation for the tank had reached a depth of 10 or 12 feet in the native rock, when the roof of the cavern was suddenly broken into, and it was found filled to the top with clay; and as it was much narrower than the intended diameter of the tank, the excavation of the rock was continued down to the floor of the cavern, viz. about 5 feet lower, thus separating the outer portion of the cavern from its inner, as shown in the following ground-plan (fig. 2).

The openings leading off from the tank on each side into the

extension of the cavern inwards and outwards were then walled up to complete the cementing of its sides, so as to enable it to retain water.

In removing the loose soil and clay from the part of the cavern thus broken into (for it was full to the roof with yellow and grey sandy clay, without any stalactites, or stalagmitic floor, such as existed in the Hippopotamus-cavern of Maghlak), a quantity of fragments of bones and teeth of at least two species of *Elephas* (one of ordinary size, but the more abundant being of a remarkable pigmy species), and other bones of extinct animals were found mingled with sub-angular and not waterworn fragments of the parent calcareous sandstone rock in which this fissure-like cavern ran, the bones and fragments being generally found lying upon the natural floor of the cavern. These had been thrown out confusedly together into an accumulated heap of soil and fragments near the mouth of the tank, and remained undisturbed at my visit.

As on examining this heap of cave soil I procured a considerable number of fragments of the same Pigmy Elephant as I had seen in the Library Museum, and which had been presented a short time previously by Signor Buttiegieg, the proprietor of the garden, I was anxious to complete the exploration of the parts of the cavern that had been walled up; and by the kind permission of the proprietor, and the assistance of his son, Padre Pietro, I had the cavern reopened on each side of the tank, and finally traced it inwards to a distance of about 75 feet. It was then traced for about 15 feet on the other side of the tank, to its original mouth opening out into the side of the valley, but which now lies completely under the soil and roots of the fruit-trees growing upon the lower terrace of the garden at about five or six feet only above the level of the rocky torrent-bed that meanders through the valley. The cavern, I found, ran nearly horizontally from the ravine, having one short branch, terminating in a small chamber as seen in the plan, and varied in height from $4\frac{1}{2}$ to $5\frac{1}{2}$ feet, with a breadth varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet, until it became contracted to a few inches only.

The results of this exploration, and a subsequent resifting of the heap of soil when dry, some months after, by the express desire of the late Dr. Falconer, yielded not only many bones of the Pigmy Elephant, but also a complete set of the tusks and teeth of this singular extinct species, in every stage of growth, mingled with which were fragments of ivory, that had evidently formed part of the tusk of a much larger but ordinary-sized elephant; yet none of the teeth of the latter were found.

All these fragments bore evidence, more or less marked, of fierce gnawing by some carnivorous animal, apparently not larger than a jackal. But it became apparent to me during the examination of these fragments that they differed entirely from the large mammalian remains from Crendi cavern, and that it in fact contained no remains of Hippopotamus.

The necessity of keeping this point in view, and the importance of identifying its relics, as being distinct from those of the Crendi

Fig. 2.—*Plan of the Zebbug Bone-cave.*

cavern, became more and more evident as the exploration^f progressed, since they had now become confused together in all local collections and in the local notices of these caverns, none of the writers having visited either cavern; and thus all idea of their special characters, as being probably indicative of two distinct geological periods or conditions of the island, was lost sight of.

Besides these relics of the Elephants, there were fragments of the large and small bones of aquatic birds, namely two gigantic Swans*, and of a Turtle, or Tortoise,—as also some few bones and jaws of the *Myoxus Melitensis* found in the Crendi cavern, and another species of *Myoxus*, figured by Dr. Carte in the 'Transactions' of the Royal Dublin Society.

IV. THE MELLIHA CAVERN.

In the Spring of 1862 I was again so fortunate as to find the vestiges of another bone-cave in Malta (namely, near the village of Melliha, at the north end of the island), a report of the existence of which had, however, been communicated to Lord Ducie and myself, five or six years previously, by Mr. St. John, then Deputy Inspector of Police; but our efforts to find it at the time did not result successfully, as the discovery was made more than 20 years previously, and but a few fragments of it had been seen by any one but the peasant who found it and utilized its débris in the walls and terraces he was constructing near the spot. But having in the early part of 1862 accidentally seen in the collection of local fossils made by Signor Pace, of the Protestant College, a fragment of the tooth of a Hippopotamus, which he had himself recently found in a wall under the village of Melliha, I was induced to make further research and inquiry at the locality for the above-mentioned ossiferous breccia. Its position was at length shown to me, at about 200 yards to the north of the church or chapel of Melliha, and in front of a cavernous cliff that fringes the north crest of the hill there, at an elevation of about 300 feet above the sea, the old chapel itself being partly formed within one of these shallow caverns, which are all at about the same level as the Crendi caverns, and were, no doubt, originated by the same cause and at the same time, the present sea-shore under the Melliha caverns being only from 200 to 300 yards distant from them. Some of the caverns have been enlarged and utilized as stables; and others were converted into rock habitations, or tombs, by the ancient inhabitants of this part of Malta.

The bone-breccia when originally discovered at Melliha was found lying at a distance of from 15 to 20 feet and more in front of one of these shallow caverns, thus showing that the roof of the cavern must have extended beyond its present limits at the time when the bones of the extinct Hippopotamus it contained were carried into it; also the breccia lying between two projecting angles of the cliff is likewise an indication of the fact of the former extension of the cavern beyond its present area, and of the great antiquity of the cavern breccia in a geological point of view.

* Described by Mr. W. K. Parker, F.R.S., Trans. Zool. Soc. vol. vi. p. 111.

The previously disturbed parts of this bone-breccia I found mingled with the walls of the adjacent terraces, and procured from them two bushels of bone-fragments, amongst which were several perfect teeth, as well as many fragments of teeth and tusks of *Hippopotamus*, as at the Crendi Cavern, but of a smaller species.

As a narrow space of about ten or twelve feet in length, and six or eight in breadth, existed between a terraced road recently made, leading to a cemetery, and the front of the part of the cavern that now remains, I dug down there to verify the information regarding the spot at which the ossiferous breccia was discovered, and was fortunate in finding a portion of the bone-breccia still *in situ*, which I broke up (more of it lies under the road), and found it also to contain fragments of bones and teeth of the same *Hippopotamus* as did the scattered fragments of the débris gathered from the adjacent terraces and walls. No remains of the *Elephant* were found here. Neither were any small bones, such as those of Rodents and Birds, found in it, or in any of the scattered fragments, as in the upper stalagmitic stratum of the Crendi cavern, and as was found also in the Zebbug cavern, commingled with the Elephant-bones; but the bones of the Birds and small *Myoxus* may have existed in the original condition of the floor of the Melliha cavern nevertheless, although not contemporary with the *Hippopotamus*, since we have now but a fragmentary exhibition of it.

V. GENERAL CONCLUSIONS.

The Melliha cavern, like the Crendi cavern, seemed, therefore, to have exclusively contained remains of *Hippopotamus* only; for not a single fragment of the tusk or tooth of either species of *Elephant* was found amongst the fragments of bone-breccia to indicate their contemporary existence with the *Hippopotamus*, although there were the remains of many individuals of the latter; and thus the time of the Melliha cavern seemed to have been associated exclusively with the remains of *Hippopotamus* of the lower stalagmitic stratum of the Crendi cavern, rather than with the Zebbug cavern, the remains in which were exclusively those of the *Elephant*; and therefore also the relics in the latter cavern are more probably linked with the *Myoxus* and Bird bones, and existing land shells, forming the upper stalagmitic stratum of the Crendi cavern.

It is remarkable that the lower part of the Crendi cavern, and the entire bone breccia (at present found) of the Melliha cavern, are characterized by the bones and teeth of the *Hippopotamus* only, and the Zebbug Cavern débris by only *Elephant*-teeth, tusks, and bones, to the exclusion of any remains of *Hippopotamus*.

Therefore the upper stalagmitic layer of the Crendi cavern, containing existing land shells imbedded with the Rodent and Bird bones, seems to bring the latter, and the associated Pigmy *Elephant* of the Zebbug cavern, down to a period more recent than the *Hippopotamus*—in fact, to a distinct and later geological epoch; for had these animals existed at the same time with the *Hippopotamus*, their

relics would have been found in some degree commingled in these caverns.

This was a point I felt it especially necessary to notice when the remains of this remarkable little species of extinct Elephant were exhibited by the late Dr. Falconer and myself, in 1862, at the Cambridge Meeting of the British Association.

It therefore opens out the following questions:—What were the times, and what were the special conditions of the locality favouring the existence of each large species of Mammalia? one being so distinctly an amphibious animal, and moreover an animal peculiar to a freshwater condition not now in any way indicated by the existing climate and region; and the other an animal exclusively of the forest and land, and thus indicating the existence, at one time, of a very proximate, if not entire connexion of Malta with Europe and Africa, by land that must have existed to serve as a highway of migration between them, but which has since subsided beneath the Mediterranean.

These submerged lands are really now indicated by the bank called the "Adventure Bank," discovered by Admiral Smyth, between Tunis and the north-west part of Sicily, as one, and no doubt the most important, highway of migration of these extinct animals, and also by another bank, which we found soon after the discovery of the Elephant Cavern of Zebbug, as a well-defined, but more deeply submerged, ridge, connecting the south-eastern end of Malta with Tripoli, and which I have named the "Medina Bank," after my ship, 'The Medina.'

So that if we were to have an upheaval of about 250 fathoms of the whole sea-bed of the Malta channel, we should have both these banks or ridges dry land, with the exception of a narrow channel through each, that would not be impassable to either animal at the seasonable times for migration; and Malta would be connected with Sicily, and Sicily with Italy, but with a deep, steep-sided and enclosed sea lying between these upraised banks, viz. between Sicily, Malta, Tunis, and Tripoli, with the extinct volcanos of Linosa Island and Graham's Shoal on either side of the basin, to show that its somewhat crater-like form, as it would then appear, from the abruptness of its sides, was really due to proximate volcanic upheaval and downcast, and that this was a basin to account for the origin of which a glacial excavation is not necessary, as seems to be the creed of some geologists regarding the greater part of such deep depressions.

And I am induced to add also, in respect to this supposed physical change in the relative positions of land and sea, that it most probably existed at no very distant geological time, and that it bore a remarkable resemblance to the Sea of Marmora, with its Bosphorus and Dardanelles as straits connecting it with the Black Sea and Mediterranean. For there would now remain, with an uplift of 250 fathoms of the entire Malta strait, a deep internal sea, nearly 200 miles long and 60 broad, and from 50 to 500 fathoms deep, and with a narrow strait between the Adventure and Medina Banks, connect-

Fig. 3.—Chart showing the position of the Adventure and Medina Banks, connecting Sicily with Africa.

The figures denote the present depths in fathoms. The dotted line shows the parts of the Malta Channel that would be converted to dry land by an uplift of 200 fathoms, and the narrow Straits that would remain through the Adventure and Medina Banks. The deepest water is indicated by the black portions, the banks by the dark tint, and the land by the light shading.

ing this basin with the east and west basins of the Mediterranean (see fig. 3).

The abundance of the remains of *Hippopotamus* that have been accumulated in the Malta caverns lying over the bold coastline of this island, as also in the caverns over the north shore of Sicily, and also in another at the level of the sea or, indeed, partially below its level, that was discovered by the late Dr. Falconer near Syracuse, seems therefore to point to the necessary existence of large areas of land and fresh water when these Hippopotami existed in great abundance, as well as of abundant vegetation and of forests at that time.* The late Mr. Leonard Horner, when President of the Geological Society, in referring to my notice of the discovery of the Crendi cavern with such abundant remains of *Hippopotamus*, in his Address for the year 1861, consequently conceived that a large river must have flowed between Malta, Sicily, and Africa, at the time these creatures were so numerous; and Dr. Leith Adams, in a subsequent notice of the Crendi cavern, adopts the same view, and thus considers that bold coast of Malta to represent the bank of an ancient river.

But the same reasoning and conclusion, if sound for the south coast of Malta in explanation of the existence there of *Hippopotamus*, must be likewise applied to the north coast of the island under the Melliha cave, and likewise to the whole of the north and east coast of Sicily opposite Palermo and Syracuse, where similar remains are found, but in much greater abundance; and therefore to suppose that a river meandered round all these coasts at one time, since the known caverns with *Hippopotamus* are all confined to the coast, involves the combination of many contingencies, for the maintenance and confinement of such a river, not usually met with, and certainly not indicated by the geological facts and physical features in connexion with either of the localities.

I therefore am induced to repeat what I have before advanced, that it seems, in my humble judgment, rather to point to a fresh-water, or perhaps brackish-water condition of the whole Mediterranean area at that time, especially as we find these ossiferous caverns mainly upon the margin of its steepest coast-line; and singularly too they are mainly over the deepest parts of the sea at present surrounding these islands; and thus where an *opposite bank* for even an unusually wide river is in no way identifiable by any existing bank or submerged ridge within those deeps, viz. not within a distance of 60 miles directly opposite the Crendi Cavern, and with a depth of 500 fathoms between, at only 5 miles from the cavern. And opposite to the Sicily caverns we must cross to Sardinia and Greece for such a feature, there being from 50 to 1500 fathoms between.

The different elevations of these caves, from those at the sea-level (as the Syracuse cavern) to others at heights of from 300 to 600 feet above it, show the great and varied movements of the whole land that have occurred since the existence of these creatures—that is, both upcasts and downcasts of considerable amount.

Now, as Malta and Gozo were most probably elevated above the sea at the close of the Miocene period (since there is no indication of any purely marine deposit of a more recent time upon them anywhere), it is therefore very possible that the caverns formed by the long action of the sea upon the first upraised zones may contain the relics of animals of more than one, if not of each, subsequent geological period; and we may possibly with reason infer that there are some of them with animal remains characteristic of one era only, and others of another, according to their local convenience, at the several periods, for the resort of the associated animals of prey, and from their size and situation &c.

Thus we may have caverns that, although formed simultaneously and at the same level, may be found to contain now the débris of extinct animals of distinct geological times, precisely as seems to be indicated by the facts before noticed in reference to the distinct Mammalia that characterize the Hippopotamus-cavern near Crendi and the Elephant-caverns near Zebbug.

Dr. Leith Adams and Captain Hutton have both communicated, through the Geological Magazine*, that they have found the remains of the Elephant in the scattered débris of subangular fragments and red earth which occur in fissures and hollows in various parts of the island of Malta, and which I believe to be due to a wave of translation rather than to river-floods, and to have resulted from a huge wave-stroke from the subsidence of neighbouring lands, or from a sudden subsidence of the greater part of Malta itself below the sea at a very recent geological period, but which subsidence was of too short a duration to produce a purely marine deposit—since no perfect marine shell is common to any of the débris, although entire land shells of existing species are very numerous.

Therefore the Pigmy Elephant and its associates seem probably to have become extinct during the Post-Pliocene period, when the subsidence took place; for fragments of this drift deposit, or débris, are found on several parts of the low coast as well as in the interior. It closely resembles a drift-deposit that occurs along the whole of the lower part of the African coast, extending between Alexandria and Tripoli, in which marine and blown sands are mingled with beds of red earth, and sometimes small subangular fragments of the adjacent rocks, as well as *entire land shells* in the sandy or red earthy deposits, just as occurs in the Malta drift-beds. It contains no entire marine shells, only small fragments of the harder marine species, showing that no tranquil condition of the waters existed for any time during the accumulation of this drift, but that it is clearly due to waves of translation that swept the adjacent plains and lower hills during sudden and brief submergences that have occurred on the African coast, at least three times on the Tripoli and Cyrene coasts and other places eastward towards Alexandria, as I have briefly shown in the Geological Appendix to 'Travels in Crete,' vol. ii.

The most instructive of these beds of débris on the coast of Malta

* Vol. ii. p. 488, and Vol. iii. p. 145.

is to be seen on the north side of the Bay of Melliha, where a bed of red vegetable soil from 4 to 5 feet thick, with subangular fragments of the parent rock, exists in a sheltered part of the bay a little above the sea-level, and is overlain by irregular beds of red earthy sand and soft calcareous sandstone, that can be traced to have reached a height of nearly 50 feet, and much more in other parts.

The sand, for the most part, seems to be an admixture of blown and drifted beach-sand, and to contain minute fragments of sea-shells, and the spines of sea-eggs, the most abundant of all living creatures in the shallows of the sea surrounding the island; *and the only entire shells in this débris anywhere are land shells of existing species, which are common.*

The explanation of such an anomalous admixture of only minute fragments of the marine fauna as a general characteristic, but with entire land shells, although so much more fragile, can only be accounted for by regarding it as the result of a huge wave that suddenly swept over the surface of the island, and was probably accompanied by a short subsidence. For the dead land shells, through being filled with air when caught up by such a wave as it rushed over the surface of the land, would, by their consequent greater buoyancy than the fragments of bones and stones and surface débris caught up with them, have floated with the silt and lighter matter, and thus have been preserved and finally deposited entire with the more earthy débris, as we find here, and exactly as I found repeated in numerous places on the north coast of Africa, and without any indication of an associated tranquil layer or bed, or any entire marine shell to indicate a subsidence sufficiently long to have caused a return of the marine fauna to it. As in excavating the new and old naval docks at Malta the same beds of red vegetable earth and fragments of surface débris with land shells were found in caverns and crevices that were broken into at 20 feet and more below the present level of the sea, there seems reason to conclude that the island has not risen again quite to the level it reached previously to this subsidence and wave-overflow from which I presume the débris to have mainly resulted.

Now I am strong in the opinion that we must give waves of translation their due power and effect in contemplating the origin of some high-level as well as low-level accumulations of similar débris, in which land shells and the bones of land animals alone exist in conjunction with small unworn fragments of the native rock. We have had many evidences in the historic and even recent times of waves of the sea having swept over lands adjacent to the coast to heights of 50 and 100 feet during earthquakes, and where sudden but comparatively small uprisings or subsidences have occurred, as on the coast of Peru and Chili.

I have previously shown the improbability of these Malta beds of débris having resulted from any ancient local river, independent of the absence of any rolled pebbles or gravel to indicate it in any manner—or even from land-floods, which, as they generally follow the low lands bordering rivers, would, I consider, have left some

rolled material intermixed with the débris. Next, glacial action cannot have been their origin in Malta—first, from their containing no transported blocks of any size to require or indicate such a moving power, and, secondly, because glacial conditions are inconsistent with the indications of a prolific land-fauna and vegetation that must have existed there, from the large quantity of the larger species of land shells (*Helix* &c.) that are found in it, independently of the Elephant-bones that are also confusedly intermingled in these beds of subangular fragments, sand, and red earth. Therefore I believe that a wave of translation was the true cause of these accumulations of *land-shell drift-beds* found in Malta and Africa, and such as my friend Mr. Busk, F.R.S., has stated to exist also at very high levels in Gibraltar; and I believe that they are generally the indications of sudden uprisings and subsidences of lands adjacent, or of the localities themselves, that have caused waves of translation and accumulation, when unaccompanied by any tranquil marine bed or marine shells, except such as have been confusedly swept up from an adjacent shore. And this general discussion of the question is probably not out of place here, from the general interest existing regarding such beds of débris and drift, and which glaciers, floods, and waves are each capable of producing, without doubt; but each have their special characters and influences, that require close study to solve, so that the great power and effect of a sea-wave accompanying sudden uprising and subsidences of broad or narrow areas of land may have their due acknowledgment in the past as in present times.

2. On the LOWER LIAS of the NORTH-EAST of IRELAND.

By RALPH TATE, Esq., A.L.S., F.G.S.

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1. *Introduction*.—From a more extended survey of the Liassic strata in the province of Ulster during the summer of 1866 than I had previously made, and from an examination of the fossils of the Lower Lias of that area, I am constrained to make some slight modifications of my views on the correlation of the members of the Lias of Ireland, as given in a paper entitled “The Liassic strata in the neighbourhood of Belfast,” published in the Quarterly Journal of this Society*.

In that paper I pointed out the occurrence of beds of Rhætic age, embracing the *Avicula-contorta* shales and the White Lias, and of beds of the age of the Lower Lias, which I had regarded as equivalent to the zone of *Ammonites Bucklandi* of the English Liassic series.

I have examined every exposure of the Lias in the north-east of Ireland, and have no reason to take exception to Sir Richard Griffith's mapping of this formation—that is, viewing the Rhætic series as a subformation of the Lias. But the principal portion of

* Vol. xx. p. 103 (1864).